Attachment 3.

Analysis of Appendix B: Evaluation of Fishing Activities That May Adversely Affect Essential Fish Habitat

TECHNICAL REVIEW
OF
APPENDIX B: EVALUATION OF FISHING ACTIVITIES THAT MAY ADVERSELY AFFECT ESSENTIAL FISH HABITAT

PART OF THE
JANUARY 2004
DRAFT ENVIRONMENTAL IMPACT STATEMENT
FOR
ESSENTIAL FISH HABITAT IDENTIFICATION AND CONSERVATION IN ALASKA

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EXECUTIVE SUMMARY

The attached report provides a technical review Appendix B of the January 2004, Draft Environmental Impact Statement for Essential Fish Habitat Identification and Conservation in Alaska (NOAA, 2004). The report evaluates the form and function of the habitat effects model, the scientific merit of the qualitative effects analysis and makes recommendations on means to constructively improve the EIS.

The influences of parameters on the habitat effect and recovery model are explored as well as the opportunities for bias in model outcomes due to the treatment of fishing effort. I demonstrate that the assumptions of the model provoke bias that both underestimates and overestimates the effects of fishing on habitat. The net effect of the bias is not determinable without a more intimate evaluation of the input data, an option unavailable to this reviewer. One interesting observation from this review is the recognition that concentrated fishing effort generates a lower global fishing effects index than more dispersed effort. A second noteworthy observation is that the equilibrium fishing effect, with rare exception, is achieved in a relatively short time.

The qualitative effects analysis of fisheries impacts on managed species (Section B.3 of Appendix B.) does not provide readers with sufficient information to appreciate the conclusions presented. An explicit depiction of the stock status relative to MSST is required as well as a clear definition of MSST. The reader also needs help to understand the interpretation of the observations presented on effects of fishing on individual species feeding and growth to maturity.

By answering key questions posed to the reviewer, I comment on the reasonableness of inferences made regarding the degree of fishery impacts on EFH, on the utility of MSST as a tool to rate fishery effects on habitat, and the notion of a global versus local perspective to address habitat effects of fishing.

Lastly, I provide some recommendations that hopefully improve the readers understanding of the analysis and their interpretation of reported outcomes.

1.0 INTRODUCTION

The January 2004, Draft Environmental Impact Statement for Essential Fish Habitat Identification and Conservation In Alaska (EFH EIS) is the most recent iteration of impact statements developed by the North Pacific Fishery Management Council (NPFMC) to meet the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (M-S Act) as amended by the 1996 Sustainable Fisheries Act (SFA). As defined by the act,

> *"The term 'essential fish habitat' means those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity."*

Sec 303 (a) (7) of the act requires fishery management plans prepared by the regional councils to *"describe and identify essential fish habitat for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat."*

National guidelines for implementing the EFH provisions of the M-S Act were finalized on January 17, 2002[1]. They are codified under 50 CFR 600 Subpart J.

Appendix B of the current draft EFH EIS (NOAA 2004), evaluates the potential adverse effects of fishing on EFH as required in 50 CFR 600.815 (a)(2)(i)-(iv) (See Appendix I of this report).

The purpose of this report is to review Appendix B, evaluate the form and function of the habitat effects model, the scientific merit of the qualitative effects analysis and to make recommendations pointing out where and how the analysis might be constructively improved. Additionally, I was asked to answer the following questions:

- Is Appendix B a reasonable approach for determining whether fishing effects are more than minimal and not temporary?
- Is MSST an appropriate standard for measuring fishery effects on managed species?
- Should the effects of fishing be viewed on a global versus local basis?

2.0 THE EFFECT AND RECOVERY MODEL

An evaluation of the form and function of the equilibrium habitat model is presented including an overview of the model, sensitivity of the model to a range of parameter values, a discussion of potential model bias due to treatment of fishing effort and an evaluation of the time necessary to achieve equilibrium.

2.1 Overview

The EFH Equilibrium Effect and Recovery Model attempts to reflect processes controlling the rate of change of habitat features between two steady states: unaffected and affected by fishing. The transformation from unaffected (H) to affected (h) habitat occurs over time as a function of fishing intensity (I) moderated by the rate of recovery (ρ) of fishing affected habitat.

Fishing intensity (I) is a function of fishing effort (f) and the sensitivity (q) of the habitat feature to a single contact by the fishing gear ($I = qf$). Sensitivity can be thought of as a modifier of fishing effort; when sensitivity is high ($q=1$) the model assumes the full force of fishing effort at work to impact habitat. Where sensitivity is lower (<1), only a fraction of the effort is assumed to impact the habitat feature (Table 1).

[1] Federal Register: January 17, 2002, Volume 67, Number 12, Rules and Regulations, pp. 2343-2383

Habitat features affected by fishing are assumed to have the opportunity to survive additional encounters with fishing gear and recover to the unaffected state. Time to recovery is variable among habitat features, some recovering quickly others slowly. The time to recovery is inversely related to recovery rate (recovery time in years = $1/\rho$). Values of ρ less than 1, correspond to a recovery time of more than one year; values greater than 1 represent a recovery time of less than one year. The recovery rate acts as a buffer to the effect of fishing.

Habitat transition from the unaffected to affected state occurs gradually over time. To generate perspective on the proportion of habitats that are likely to be affected by fishing, the model assumes that fishing intensity and habitat recovery rates are constant for all time, such that habitat features eventually achieve a balance or equilibrium between these two states. The equilibrium effect is called the Long-term Effect Index (LEI).

The LEI represents the proportion of the habitat features lost as a consequence of impacts from fishing. In the model, fishing-affected habitats are assumed to have no functional value in support of sustainable fishery resources. In my opinion, this assumption overstates the effects of fishing since affected habitats may retain some of their functional value. For example, a toppled sponge or broken coral may still provide structural cover even though affected by fishing. Habitat features that recover faster can withstand higher rates of fishing intensity and produce the same LEI score as features with longer recovery rates but lower fishing intensity.

The LEI score is computed deterministically, i.e., the LEI function has a closed form solution, once the ρ and I parameters are input to the model a score is generated. Although the parameter values may have some variability, they are input to the model as if they are known without error. Consequently, there are no precision estimates (confidence intervals) for the LEI scores. The analysts test model sensitivity by providing a range of parameter values (low, central and high effect).

2.2 Key Equations

$$(1) \quad LEI = 100\,(1 - Heq) = 100\left(1 - \left(\frac{H_0\ \rho e^{-I}}{I + \rho e^{-I}}\right)\right)$$

where, LEI is the percentage of fishing affected habitat at equilibrium, H_{eq} is the quantity of unaffected fishing habitat at equilibrium, H_0 is the quantity of unaffected fishing habitat at time zero, *e* is the exponential constant (2.718), and ρ and I are the recovery and fishing intensity parameters discussed above.

Given a continuously applied amount of fishing effort, habitat feature sensitivity and recovery rate, habitat features will transition from unaffected to affected over time. The estimated amount of unaffected habitat at a specific point in time (H_t) is calculated from:

$$(2)\quad H_t = \frac{H_0\left(I\,e^{-(I+\rho S)\,t} + \rho S\right)}{\left(I + \rho S\right)}$$

where, $S = e^{-I}$ is the survival rate of fishery affected habitat. By setting H_0=1, and evaluating Equation (2) over a range of I and ρ parameter values, we can estimate how quickly we approach the equilibrium condition.

2.3 Parameter Values (I, ρ)

I did not attempt to evaluate the derivation of the habitat feature sensitivity or recovery rate parameter values depicted in Tables B.2-5 and B.2-6. Suffice it to say, that direct observations of habitat sensitivity and recovery rates in Alaskan waters are sparse. Of the 31 published citations listed on Table 3.4-35 of the EFH EIS, only four address fishing effects on habitat in Alaska (field work is completed on an additional three studies). Analysts provide a subjectively assessed quality score to rank the dependability of the assigned parameter values. A score of 10 implies precise information; a value of 1 represents the greatest uncertainty. Quality scores for habitat sensitivity of bottom trawl averaged 4.9, pelagic trawl 2.5, longlines 2.1 and pot 1.2. Recovery rate quality scores average 3 to 3.3 for different substrate types (mud, sand, silt, pebble, rock). Overall, the habitat sensitivity and recovery rates used in the equilibrium model are judged more uncertain than certain.

While measures of habitat sensitivity in Alaskan waters may be limited, measures of fishing effort are not. Fishing effort was estimated by overlaying a grid of 5 x5 km blocks throughout the Bering Sea (BS), Aleutian Islands (AI) and Gulf of Alaska (GOA). Fishing effort as measured by at-sea observers was converted to area swept (Table B.2-4) for all gears fished within a block. Area swept was divided by total block area to generate an effort score for each block (% area swept). The fishing effort index value (f) is the weighted average of fishing effort over the 5-year period 1998-2002. When $f < 1$ the total area swept within the block is less than the area of the block, when $f \geq 1$, the total area swept during fishing exceeds the total area of the block.

Within the EFH EIS and specifically within Appendix B, there is no display of the effort values input to the EFH Equilibrium Effects and Recovery Model[2]. Readers should have better insight to this key data element. The distribution of effort is highly skewed with the majority of blocks displaying low effort. Given the fixed levels of habitat sensitivity to fishing, fixed recovery rates, and the deterministic calculation of the LEI, one can estimate the fishing effort level necessary to provoke any given LEI value. No one knows how much habitat loss is required to adversely affect the sustainable production of managed species. I arbitrarily chose an LEI value of 50% or higher as a value one might suspect of provoking a detectable effect of fishing. I then proceed to determine what

[2] There are GIS figures displaying maps of fishing effort as sets/25 km^2, see Volume I, Chapter 9, Figures 3.4-6 through 3.4-33. The map legend indicates three categories of effort (high, medium, and low) but does not list the sample size associated with each of the categories. There are no depictions of effort as percent area swept.

level of fishing effort was necessary to generate LEI values of this magnitude. As shown below in the discussion of parameter sensitivity, effort values typically need to be greater than 0.3 to generate LEI values of 50% or more. I then wanted to know what fraction of the blocks received effort at this level.

I obtained a sample of the fishing effort distribution for the Bering Sea pelagic trawl pollock fishery, the Aleutian Island bottom trawl Atka mackerel fishery and the Gulf of Alaska bottom trawl rockfish fishery (Figure 1). Total habitat area for each major region (BS, AI, GOA) is shown on Table B.2-7 in Appendix B. Each fishery represented in Figure 1 fished a small fraction of the total area: 21% for the BS pelagic pollock fishery, 8% for the AI Atka mackerel fishery and 7% for the GOA rockfish fishery. Within the fished habitats 87 to 92% of the area was fished at low levels of effort ($f \leq 0.3$). For these fisheries, the higher effort occurs in a small subset of habitat blocks: 10-13% of the fished area, and 1-3% of the total area. This helps to explain why the overall LEI values are so low.

Effort is the most significant data element input to the model. It is also the most objectively measured data element. Analysts could help readers achieve a better insight to the expected LEI outcomes by providing information on the distribution of fishing effort. Therefore, it would be informative to include figures and/or tables of the distribution of fishing effort input to the model. The analysts may also want to provide complementary LEI distribution histograms.

<u>2.3.1 Treatment of effort sampling bias</u>. I evaluated at least three sources of bias associated with assumptions regarding fishing effort. The first two effects are associated with the assumption of a uniform distribution of effort within each 5x5 km block: 1) the effect of either a patchy distribution of fishing effort, or a patchy distribution of impacted habitat, and 2) the effect of overlapping effort from repeated sets along the same fished path. The third source of bias stems from the assumption that all effort can be assigned to block based on fishing end points.

Effort for unobserved vessels (those <60') was not included in the model. Effort from vessels with partial observer coverage (those 60 to 125') was expanded to account for the coverage rate. In doing so, the analysts assumed that the spatial distribution of the observed effort was identical to the distribution of the unobserved effort. If the spatial distribution of unobserved sets differs from that of the observed sets, the LEI values will be biased. The direction of this bias is not calculable.

The effort distribution does not represent the precise footprint of the fishery within each block. Effort is assumed to be uniformly distributed within a block. For a given fishery and habitat feature, each haul or set is assumed to have the same impact on that feature. If effort is significantly overlapping, this assumption results in an overestimate of the effects of fishing on the habitat. Whether overlapping or not, The LEI scores can also become biased when effort or habitat is patchily distributed within a block. If the habitat is patchily distributed and effort is uniform throughout the block, then the LEI scores will not be affected by the distribution of habitat, there is no bias. If both habitat and fishing effort are patchily distributed, then there can be errors in the estimated LEI, and the direction of bias will depend on the overlap of the effort and habitat feature. If there is high effort in an area of low habitat density or low effort in an area of high habitat density the presumptive LEI as calculated in the model will overestimate the fishing gear effect. If there is high effort in an area of high habitat density, the habitat model will underestimate the actual fishing effect.

Effort was assigned to blocks based on haul or set endpoints. There was no attempt to prorate the distribution of effort to accommodate hauls and sets that crossed over more than one block. Errors associated with this simplification are assumed to balance out, with the consequence that some blocks may be characterized with a higher intensity of fishing than they actually realized and vice versa. However, failure to prorate effort appropriately can undervalue the effect of fishing on habitat.

Undervaluing the effect of fishing on habitat is demonstrated using the following hypothetical: effort is distributed equally between two adjacent blocks with all fishing endpoints occurring in Block 1. Accordingly, model effort is assigned entirely to Block 1 (assigned effort distribution Block 1: Block 2 = 100:0 while the actual distribution is 50:50). Under these circumstances the cumulative LEI score for both fished blocks is undervalued, i.e., the fishing effect is actually more severe than that represented in the model (Figure 2). The bias lessens as the actual effort distribution approaches the assigned distribution, but the bias always favors undervaluing the fishing effect. The extent of the bias predominately depends on the recovery rate for the affected habitat. As the time to recovery gets longer ($\rho < 1$), the bias gets larger. Habitat sensitivity also affects the bias, with the bias becoming less severe as sensitivity diminishes.

The necessary assumptions employed in the construction of the habitat effects model can lead to biases that both underestimate and overestimate the actual effects of fishing. With the information available, we are unable to determine what the net effect of the bias will be. One interesting observation of the evaluation of assumptions associated with fishing effort is that all else being equal concentrated fishing effort will generate a less severe overall fishing effect (lower LEI) than highly dispersed effort. This observation is discussed further in Section 4.3.

2.3.2 Parameter sensitivity. I evaluated the sensitivity of the habitat model over a range of parameter values. I did so by holding one of the three parameter values constant and varying the other two (Figure 3). Some of the outcomes are obvious. For example, regardless of the habitat feature sensitivity to fishing if the recovery rate is very long, i.e., for a constant q and as $\rho \to 0$, the LEI goes to 100% provided there is any fishing effort at all (open triangles in Panels A and B, Figure 3). This is understandable since even a small amount of effort will have some impact on habitat features, and without recovery, that effect will eventually accrue to all habitats. Conversely, as habitat feature sensitivity goes to zero, and the effects of fishing gear on habitat become negligible, the LEI approaches a value of zero (open triangles Panel C and D, Figure 3). If the fishing effort doesn't adversely affect the habitat in the first place, then it makes no difference how long it takes the habitat to recover from an effect; the impact will still be zero.

Intermediate parameter values are illustrated in the curves marked by solid rectangles in Panels B and D of Figure 3. These curves show that the LEI value increases asymptotically toward 100% with increasing fishing effort.

Fishing intensity (I) is the product of habitat feature sensitivity (q) and the fishing effort index (f). For fixed rates of recovery (ρ), as I increases the LEI value increases, i.e., fishing effects become more severe. For fixed levels of fishing intensity (constant q), LEI values decline exponentially (fishing effects become less severe) as the time to recovery becomes shorter, i.e., as $\rho \rightarrow \infty$ (Figure 4).

The more severe equilibrium fishery effects (LEI $\geq$ 50%) are associated with a longer recovery period (small values of ρ) and higher fishing intensity (larger values of I). LEI values typically exceed 50% for $\rho \leq 0.18$ and $I \geq 0.04$ (Table 2.) The working parameter space for q and ρ are set in Appendix B, Tables B.2-5 and B.2-6. For most of the q values, the fishing mortality index level (f) has to be greater than 0.3 to produce fishing intensity levels larger than 0.04. As shown for a select set of fisheries, a very small fraction of the total regional habitat is fished at f levels larger than 0.3 (Figure 1).

<u>2.3.3 Time to Equilibrium</u>. To determine how long it takes an unaffected habitat to come to equilibrium with a specific level of fishing intensity, I used Equation (2) above. Assuming all habitat was unaffected at time zero, and using recovery rates of 1 and 20 years (ρ = 1 or 0.05), and fishing intensity rates from 0.01 to 0.2, I iteratively computed the H_t values for a range of years. The time necessary to achieve equilibrium varies with both fishing intensity and recovery rate (Figure 5). For a given rate of recovery, it takes longer to reach the equilibrium condition at lower fishing intensity than it does at higher fishing intensity rates. For short recovery times (ρ = 1) equilibrium is reached rather quickly, about 10 years; while for the longer recovery time (ρ = 0.5) reaching equilibrium can require up to 100 years. Because the equilibrium condition is approached asymptotically, for short recovery times you achieve 98% of the equilibrium effect within 4 years, even at the lower levels of fishing intensity evaluated. For the longer recovery times and lower fishing intensity rates, you can achieve about 80% of the equilibrium effect in 30 years. The BSAI and GOA groundfish fisheries have been fished for 27 years under the M-S Act. In my judgment, it is therefore reasonable to assume that except for those features with the longest recovery rates (hard corals), for all intents and purposes we should expect that EFH has come to equilibrium with the effects of fishing. If the effects of fishing on habitat have reached or nearly reached the equilibrium condition, then any adverse effects of fishing on productivity of the managed species should have manifest itself by now.

3.0 MSST

The method used to determine the groundfish MSST level used in the interpretation of fishing effects on habitat is not defined in Appendix B or elsewhere in the EFH analysis. Throughout the EFH EIS and particularly within Appendix B of the EIS, there is repeated reference to minimum stock size threshold (MSST). This threshold stock level is utilized in Appendix B to make a judgment regarding the sustainability of managed fish resources. Stocks above the MSST biomass are presumed to be sustainable. The assumption is that a sustainable stock resides in an environment with all the necessary features to maintain its productivity. Therefore, by extension, the effects of fishing on EFH supporting those stocks can be interpreted as minimal or temporary requiring no specific mitigation under the EFH rules of the M-S Act. (See the EFH EIS, Appendix B, Section B 3.1, p B-24 to B-26).

> The "*… resulting analysis of stock status relative to MSST was used by evaluators as an indicator of effects of recent fishing intensities on managed species and their EFH. Evaluators were knowledgeable of any peculiarities in their species' history that would make this indicator more or less relevant. In the absence of other indicators, a positive MSST analysis justified a rating of minimal or temporary effects.*" (p B-25)

NMFS has invoked the MSST standard as a measure of sustainability without a specific definition of MSST as used in this analysis. Goodman et al (2002), reviewed the chronology of groundfish harvest rules adopted by the NPFMC. They report that the Council's current Tier system for determining groundfish acceptable biological catch has no specific definition of MSST (see p. 64, Section 3.5.1).

MSST is a concept put forward in the NMFS Federal Register final rule on the M-S Act National Standard Guidelines. It is codified in the rules discussing overfishing at 50 CFR 600.310 (d)(2)(ii):

> "*A minimum stock size threshold or reasonable proxy thereof. The stock size threshold should be expressed in terms of spawning biomass or other measure of productive capacity. To the extent possible, the stock size threshold should equal whichever of the following is greater: One-half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the maximum fishing mortality threshold specified under paragraph (d)(2)(i) of this section. Should the actual size of the stock or stock complex in a given year fall below this threshold, the stock or stock complex is considered overfished.*"

To meet requirements put forward in the National Standard Guidelines, NMFS has required that annual groundfish status of stocks reports determine whether managed fisheries resources are overfished or approaching an overfished condition. In doing so, the NMFS/AFSC has adopted internal procedures for judging whether a stock of groundfish is above or below its MSST (Appendix II) and therefore whether or not it is overfished as defined in the M-S Act. These procedures are incorporated into the annual groundfish Stock Assessment and Fishery Evaluation (SAFE) reports as stock projection scenarios #6 and #7 (See 2004 BSAI groundfish SAFE, Introduction p 8-9):

NMFS employs a three-part rule for determining a stocks condition relative to MSST:

1. $B_t \geq B_{MSY}$, the stock is <u>above</u> its MSST;
2. $\frac{1}{2} B_{MSY} \leq B_t < B_{MSY}$, stock biomass must be projected 10 years at $F = F_{OFL}$ to determine status relative to MSST,
   a. $B_{t+10} \geq B_{MSY}$, the stock is <u>above</u> its MSST,
   b. $B_{t+10} < B_{MSY}$, the stock is <u>below</u> its MSST;
3. $B_t < \frac{1}{2} B_{MSY}$, the stock is <u>below</u> its MSST;

where, B_t is the estimated spawning biomass for the upcoming harvest year t, B_{MSY} is the equilibrium spawning biomass associated with fishing mortalities that generate the maximum sustainable yield (F_{MSY}); F_{OFL} is the overfishing mortality rate; and, for those stocks assessed under Tier 3 harvest rules, B_{35} is the proxy for B_{MSY}. These are the apparent rules used in Appendix B section B.3.2 to judge whether groundfish stocks were at or above their MSST levels and therefore sustainable.

Current groundfish stock size is unequivocally at or above MSST if it exceeds B_{MSY}. However, if stock biomass is between ½ B_{MSY} and B_{MSY}, stock biomass must be projected 10 years to make a determination whether or not the <u>current stock condition</u> is classed above or below MSST. In this circumstance, the projected stock biomass has to be greater than or equal to B_{MSY} by year 10 for the near term classification to be "above MSST". Therefore, current stock size can be <u>as low as ½ B_{MSY} and still be classed above MSST</u>. If the current stock size is below ½ B_{MSY}, it is definitely below MSST.

4.0 COMMENT ON KEY MCA QUESTIONS

<u>4.1 Is Appendix B a reasonable approach for determining whether fishing effects on EFH are more than minimal and not temporary</u>?

The analytical approach used to evaluate fishery effects on habitat seems reasonable. The analysts defined properties of the fishing gear; determined the sensitivity of habitat features to contact with the gear, evaluated the rate of habitat recovery absent fishery impacts; measured the quantity and spatial distribution of fishing effort; and in an innovative model, objectively scaled the impacts of that effort on vulnerable habitat. They then made a determination, utilizing modeled outcomes of fishery impacts on habitat, and life history and demographic data of managed species populations to draw conclusions as to the relative magnitude of fishery effects on the EFH supporting managed species.

The analysts have been reasonable in identifying the fishery effects that are more likely versus less likely to have adverse effects on habitat. Much of the discourse on the effects of fishing on habitat derived from the review of relevant literature addresses the measurable changes in habitat structure and/or species diversity in fished versus unfished habitats. However, the effect of these changes on the sustainability of managed species remains highly speculative. While we can follow the logic of the arguments presented by the EFH analysts in support of their determinations, the scientific information supporting inferences on fishing effects on EFH in Alaskan waters is so sparse, and the analytical assumptions so critical that the conclusions may not be robust.

There are no established standards for judging the degree of fishery impacts on habitat. The analysis in Appendix B evaluates three sets of information used to make a determination of the managed species response to fishery impacts on EFH. The analysts return to the definition of EFH and look for detectable impacts on managed species 1) feeding, 2) growth to maturity, and 3) spawning and breeding. The summary results of that analysis are displayed in Appendix B, Table B.4-1. In every instance the analysts conclude that the effects of fishing on EFH are either minimal or unknown.

At the species level, the qualitative analysis provided in Section B.3 of Appendix B supporting the "minimal and temporary" findings could be improved with a more systematic representation of the available information for each species. For example, to help the reader understand why the fishery impacts on EFH have minimal impacts on managed species feeding, show the dependence on the top three prey species, the association of prey with habitat features (infauna, epifauna, etc.), the proportional dependence of that prey in the diet of the managed species, and vulnerability of the prey to fishing impacts. To help the reader understand why fishery impacts on EFH have a minimal effect on growth to maturity, present a figure of changes in mean size-at-age over time so we can judge the effects of growth to maturity. Finally, to help the reader understand why fishery impacts on EFH have had a minimal impact on spawning and breeding provide a figure of the trends in spawning biomass and recruitment over time so we can see the relationship to sustainable stock size. Guide the reader to understand what characteristics of these indicators might be indicative of a more than minimal habitat effect on feeding, growth to maturity and spawning and breeding.

The most commonly invoked defense of the analytical conclusions that fishery effects on habitat are minimal is the overall abundance of managed species. This phrase is systematically repeated in the evaluation of groundfish species, "*As determined in the Draft Groundfish Programmatic SEIS (NMFS 2003), nothing in the current fishery management regime jeopardizes the ability of the* [name the species] *stocks to maintain themselves at or above their respective MSSTs. Therefore, the effects of the reductions in habitat features on spawning/breeding and growth to maturity are either minimal or temporary...* " The utility of this indicator is discussed below in the question addressing MSST. Whether or not you accept stock size relative to MSST as an indicator of sustainability and habitat health, there is not enough evidence placed in the EFH analysis to show that the evaluated stock meets or exceeds this standard.

<u>4.2 Is MSST an appropriate standard for measuring fishery effects on managed species</u>?
The central issue is whether it is defensible to assert that the managed species EFH is minimally impacted by fishing if the species stock condition is sustainable? This top down measure of the effect of fishing on habitat depends on the notion that the trends in

population abundance integrate the cumulative impacts of all natural and anthropogenic forces affecting population sustainability. A stable and productive stock biomass, it is argued, must be a product of a stable and healthy environment (within the natural bounds of variability). MSST was chosen as the biomass threshold to judge stock sustainability for its consistency with overfishing definitions in the M-S Act; thus, a stock is sustainable if it is neither overfished nor approaching an overfished condition.

If population trends vary in proportion to fishery impacts on habitat, the MSST standard for sustainability could be thought of as a coarse measure of habitat health. The measure is coarse because there are other influences on population trends that could cover or mask adverse effects of fishing. Additionally, stocks can be sustainable over a wide range of stock size; the definition of sustainability is a policy choice. To use sustainability as a measure of habitat health, the standard has to have standing as one that assures healthy habitats. Our current standard for sustainability is one that assures maximum yield (catch) from the fishery. Moreover, the absolute level of the existing standard is revised annually based on the trends in stock recruitment; it can go up and it can go down. If effects of fishing on habitat have already been realized, and their impact on stock productivity felt, then the current stock biomass and MSST reflect those changes in productivity and the argument that biomass is an indicator of minimal habitat impact becomes circular.

A second issue associated with using a biomass level as an indicator of the fishery effects on habitat is how to interpret the test when the stock is above and below the target biomass level. Currently, the assertion is that the fishery impacts on habitat for stocks above MSST are minimal. If this test is treated as a two-tailed test, then stocks below MSST would imply more than minimal effects of fishing. There is dissention among interest groups regarding the level of stock biomass that represents minimal fishery habitat impacts. For some, ½ B_{MSY} is too low of a biomass standard and they would suggest raising it. Since we expect managed species population abundance to vary around B_{MSY}, using a two-tailed test, the probability of becoming classified as adversely impacting fishery habitat increases as the standard is raised toward B_{MSY}.

The sustainability standard could be treated as a one-tail test. In this fashion, fishery habitat impacts for stocks above the standard would be treated as presumptively minimal. If stock biomass is below the standard, we could make no conclusions on the impact of fishing on habitat. Under this circumstance, other factors would have to be brought to bear to draw the inference. Because it requires additional information to judge fishery effects on EFH when stock abundance is below the biomass standard, the one-tailed test is less precautionary than the two-tailed test, and is likely to be unsatisfactory to advocates for habitat protection.

Another weakness of the biomass standard as an indicator of fishery impacts on habitat is the obvious opportunity to draw false conclusions from the test (Type II errors). Scientists recognize that environmental conditions over large regions periodically shift (Hare and Mantua, 2000). For example, the regime shifts in the Bering Sea are thought to be responsible for the significant increase in gadoid year-class strength in the 1970s.

Climate influences on recruitment can move populations towards a period of lower or higher productivity. If a population falls below its MSST under the influence of climate, invoking the stock sustainability standard would result in a determination of more than minimal effects of fishing on habitat when there was no such impact. Conversely, there could be a time lag between the effects of fishing on habitat and the change in stock size. Consider a hypothetical example: if removal of living shelter had a subtle but negative impact on juvenile fish survival and subsequent recruitment to the fishable population, over time, year-class strength would decline, recruitment variability may be dampened and the stock's overall resilience impaired. While these changes are occurring, the stock may give the appearance of remaining sustainable; we might regard the declining year-class strength as indicative of adverse environmental conditions (an effect of climate) when the culprit was adverse effects of fishing on EFH.

With time, scientists may be able to make the empirical observations required to define the threshold levels of fishery effects on habitat that are associated with sustainable production of managed species. The task is daunting and the challenge of segregating the effects of environment from the effects of fishing seems very difficult. Until such time, we are forced by circumstance to proceed as we are with the best available science and a healthy dose of common sense.

In my view, the MSST standard employed in the EFH analysis is a coarse indicator of fishery impacts on EFH. Promoting the use of this standard as a one-tailed test would be most appropriate. It is more acceptable in my mind to conclude that a strong, sustainable fished population is maintained via healthy habitats, than it is to conclude that a declining population implies adversely impacted habitat. I would be more suspicious of an excessive level of fishing under the latter circumstance than I would be of an adverse impact on habitat. Nevertheless, I believe the common sense approach of using a biomass threshold as an indicator of habitat health, might be viewed more positively if the standard was moved to B_{35} rather than ½ B_{35}. Given the present abundance of Alaskan groundfish stocks, the impact of moving the standard is minimal. Currently, none of the stock abundance projections in the PSEIS are below ½ B_{35} (Table 3). The GOA pollock stock which is estimated to be below B_{35} in 2002, is projected to be above this threshold biomass by 2010. Thus even at the higher threshold level, using the PSEIS stock projections, all stocks would remain classified as sustainable.

Because the observation of sustainable stock size weighs heavily on the interpretation of fishery effects on habitat, raising the biomass standard may provide some comfort to those concerned with this inference. Whether a higher biomass threshold is used or not, the rigor of the inference that fishing impacts on EFH are currently minimal is strengthened by cumulative indicators of fishery impact, i.e., healthy stocks, low levels of fishing effort, low habitat sensitivity to fishing, and fairly rapid recovery rates from the effects of fishing.

4.3 Should the effects of fishing be viewed on a global versus local basis?

In trying to consider the context for addressing global versus local effects of fishing on EFH, I took into consideration what I perceived as the intent of the law as articulated in the implementing regulations, the biological demands of the managed species and consequences of the redistribution of fishing effort.

I believe the guidelines for evaluating EFH take a global view over the local view. In the final rule developing the guidelines for implementation of the EFH provisions of the M-S Act there are multiple references to the concerns for healthy ecosystems and for sustainable populations, for example:

> 50 CFR 600.815 (a)(1)(iv)(A)
> "*Councils should analyze available ecological, environmental, and fisheries information and data relevant to the managed species, the habitat requirements by life stage, and the species' distribution and habitat usage to describe and identify EFH.*"
>
> 50 CFR 600.815 (a)(1)(iv)(E)
> "*Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species. ... The extent of the EFH should be based on the judgment of the Secretary and the appropriate Council(s) regarding the quantity and quality of habitat that are necessary to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem.*"
>
> 50 CFR 600.815 (a)(5)
> "*To the extent feasible and practicable, FMPs should analyze how the cumulative impacts of fishing and non-fishing activities influence the function of EFH on an ecosystem or watershed scale.*"

The apparent intent of the M-S Act is to protect EFH as a means to maintain the sustainability of the managed species throughout their range.

In my view, EFH assumes local over global consideration for a managed species at the point where we identify a limited range of available habitat that is absolutely essential to the survival of the managed species and vulnerable to the effects of fishing. In ecological parlance, the relationship between the managed species and the habitat would be termed an obligate habitat association. The closest example I can think of for managed species is the use of crevice habitat by Atka mackerel for attachment of their eggs during spawning. To the extent that availability of such habitat limits stock production, and fishing adversely affects availability, fishing impacts should be mitigated. However, if the association is obligate but the habitat is abundant (not limiting) despite effects of fishing, then there is no need to mitigate fishing effects to maintain the sustainable production of the managed species. The controlling elements of this consideration of local fishing effects are an obligate habitat association and limited habitat supply.

Consideration of a local versus global view of EFH stems from concerns that localized high intensity fishing may adversely affect EFH. Some have argued that mitigation for adverse effects of fishing on habitat is required where fishing is most concentrated. The apparent hypothesis behind this assertion is that concentrated fishing occurs at locations of preferred fish habitat; fishermen seek out high fish densities and density must be high because the habitat is preferable; high fishing effort in these locales must therefore diminish the quality of this preferable habitat. However, fishermen concentrate their effort for a multitude of reasons, not the least of which is to maximize the economic return for a given level of cost. Effort may also be concentrated to avoid regulatory sanction, e.g., to avoid high bycatch and the attendant constraints that accompany it. Regardless of the reason for the concentration of effort, the issue becomes one of whether or not the productivity of the managed species is substantially reduced due to the concentration of fishing, i.e., whether species abundance remains sustainable; conversely, whether the habitat is better off with effort dispersed. Presently, there is no empirical evidence that the managed species in Alaskan waters are not sustainable.

Duplisea et al. (2002) explored the environmental consequences of fishing on North Sea infauna. By modeling expectations for changes in infauna resulting from variable rates of beam trawling and contrasting their expectations with empirical observation, the authors noted that certain categories of infauna should have been eliminated from the environment but were not. They explained the persistence of these organisms on the patchy distribution of fishing effort. Whereas, the modeled expectations assumed uniform distribution of effort, the successful survival of vulnerable infauna could only occur if the assumed effort distribution were incorrect. The authors concluded, "*We suggest that management measures that reduce patchiness in trawling disturbance or affect the persistence of spatial patterns in effort over time are likely to have greater effects on benthic communities than those that encourage small areas to be fished repeatedly.*"

The habitat effects of concentrated versus dispersed fishing effort are conveniently illustrated in Figure 1. In this illustration, concentrated effort is represented by the upper panel series with open diamonds and uniformly dispersed effort by the series marked with X's. Dispersed effort routinely produces a larger LEI value, i.e., a more severe fishery effect, than that of the concentrated effort. Lower habitat recovery rates (a longer time to recover) exacerbate the differences between the dispersed and concentrated effort.

Displacing effort from fishing hot spots only increases effort on lesser impacted areas. Moreover, a hot spot is by definition a high CPUE area. Displacing effort to lower CPUE areas means that the absolute amount of effort needed to catch the allotted fish will increase, further exacerbating the impacts on habitat. If one followed a procedure of repeatedly identifying the fishing hot spot and displacing the effort the end result would be a serial closure of fishing grounds until the fleet were left with the least productive grounds fished at a maximum level of fishing effort. Thus, displacing effort from high CPUE to lower CPUE areas is incongruous with the intent of the Act.

5.0 RECOMMENDATIONS

References to projected stock biomass from the draft PSEIS should be replaced with the specific stock biomass values used to judge stock sustainability. There should be a plot and/or table of current stock sizes with ratio estimates of the current stock size to the target stock size. As shown in the draft PSEIS, projected 2002 stock biomass for assessed species in management Tiers 1-3 are typically well above the MSST of ½ B_{MSY} (Table 3). Unless they deliberately seek out the information from the PSEIS, this observation is unavailable to readers of the EFH EIS,

It would be my preference to delete the reference to MSST changing the language to "target sustainable biomass". This would obviate the connotation that stocks are evaluated against their "minimum allowable biomass."

The qualitative analysis provided in Section B.3 of Appendix B supporting the "minimal and temporary" findings could be improved with a more systematic representation of the available information for each species. There needs to be an explanation of why the effects of fishing on feeding, growth to maturity and spawning and breeding are judged no more than minimal. I provide some recommendations on how one might show this in Section 4.1 above.

The arguments for minimal fishery impacts on EFH made individually for each managed species might be strengthened by rating the overall stock condition of the group of managed species that utilize the habitats evaluated (the depth zones of the AI and GOA, and the substrate zones of the EBS). The notion here being that if the evaluation of fishery habitat effects on individual species is consistently minimal, then the recognition of multiple healthy stocks within a habitat zone amplifies the inference that habitat is minimally impacted. Multiple stocks utilize the habitat differently one from the other. If the impact of the fishery on habitat were severe one might expect to observe an effect on multiple species in the region.

Appendix B should include frequency histograms of the effort distribution for each fishery listed in Table B.2-3. In addition the cumulative effort frequency histograms for each habitat strata within a region should be presented. Readers would have a better opportunity to evaluate the proportion of high versus low intensity fishing areas if these figures were available. Complimentary histograms of the LEI distribution would also be useful.

MCA should promote increased research to evaluate effects of fishing gear on habitat in Alaska. They should give consideration to the establishment of research areas located within high intensity fishing corridors. Although NMFS is working to improve their understanding of the effects of fishing gear on habitat, specifically designed test and control areas would benefit the process.

6.0 ACKNOWLEDGEMENTS

During the review of this material I had conversations with Drs. Craig Rose, Anne Hollowed, and Dan Ito all of the NMFS-AFSC ; and, Dr. Jeff Fujioka, NMFS-ABL. Their cooperation in addressing my questions was greatly appreciated.

7.0 LITERATURE CITED

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8.0 FIGURES

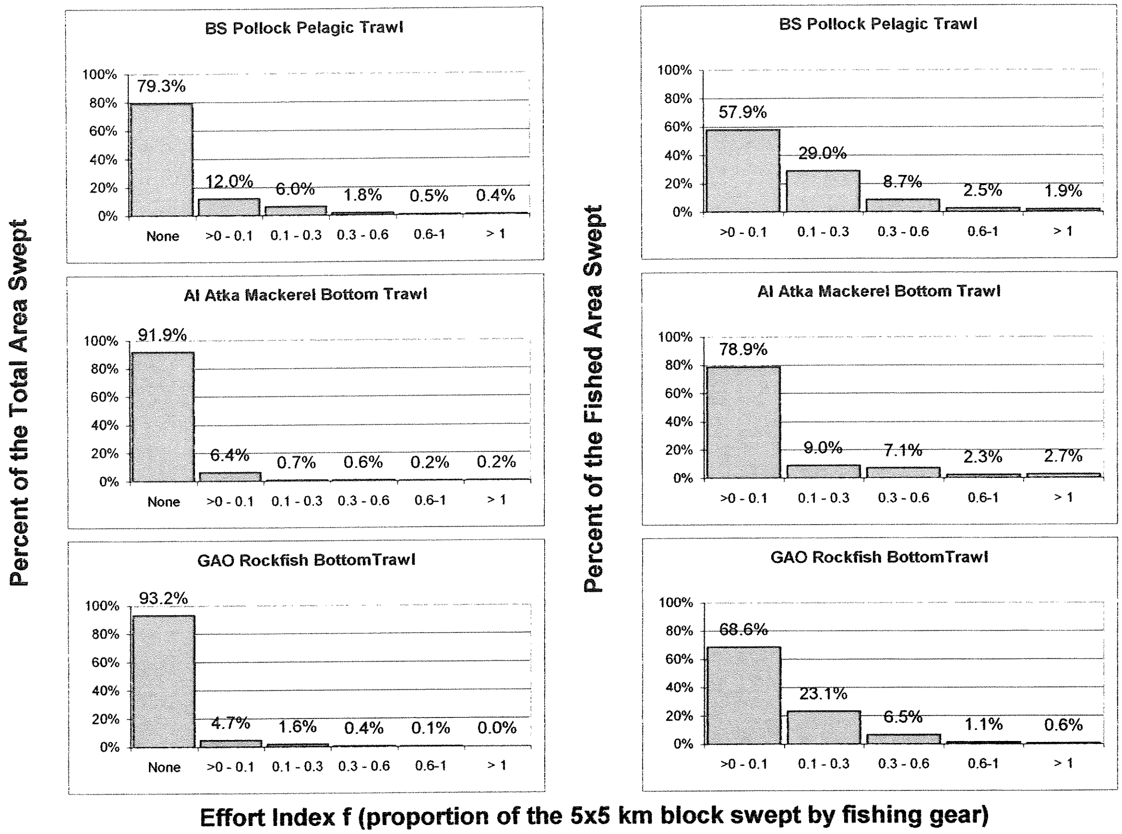

Figure 1. Distribution of 1998-2002 average area weighted fishing effort (f) for a select set of trawl fisheries. (Data provided by Craig Rose, NMFS-AFSC 3/24/04)

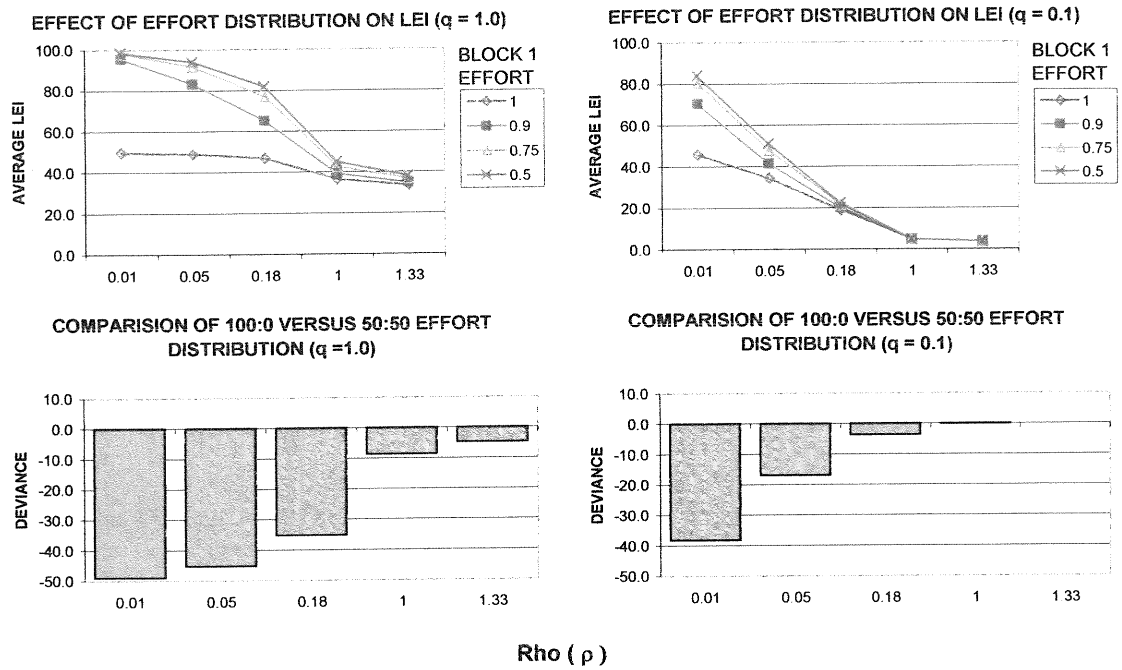

Figure 2. LEI bias associated with the distribution of fishing effort across blocks. For 2 hypothetical blocks, each series in the upper panel represents the distribution of effort between Block 1 and Block 2 (100:0, 90:10, 75:25, 50:50). The fishing effects on habitat are more severe when effort is uniformly distributed across blocks (top panel, X's) than it is when effort is concentrated (open diamonds). The bias decreases as ρ increases (as recovery time shortens). Habitat sensitivity also effects the bias, with the bias becoming less severe as sensitivity diminishes.

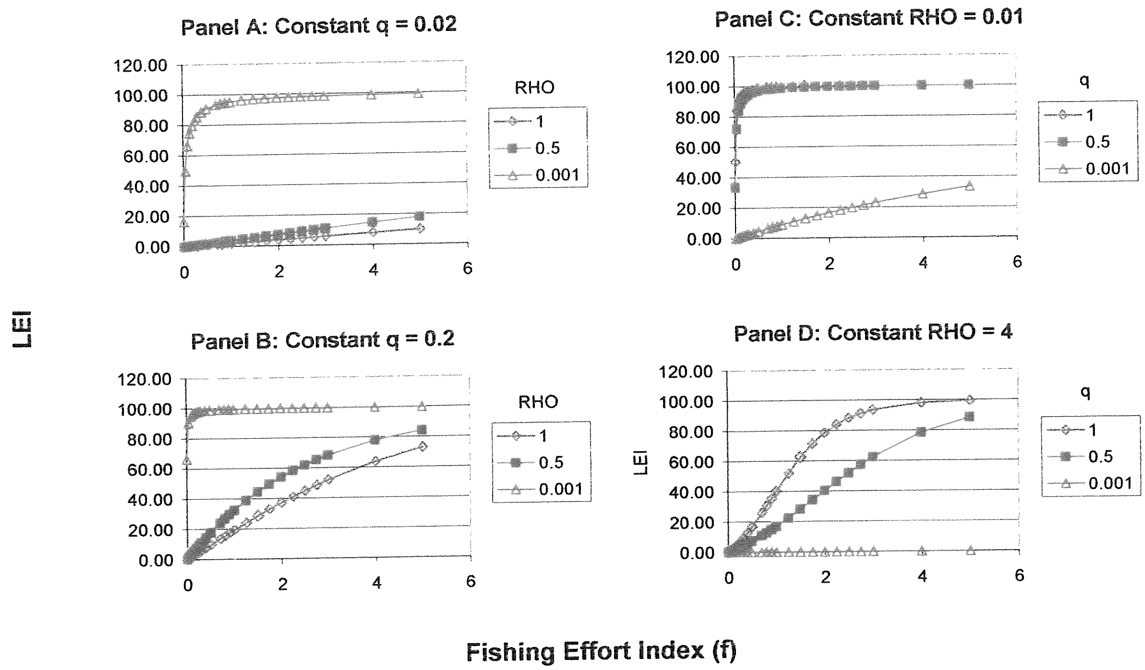

Figure 3. Trends in the LEI index for a range of habitat sensitivity (q) and recovery rate (ρ) parameter values. (Constant q and ρ values reflect the central value range displayed on Tables B.2-6 and B.2-6, while the q (Panel C and D) and ρ (Panel A and B) values for each of the three graphed series reflect variability between extreme and moderate parameter values.)

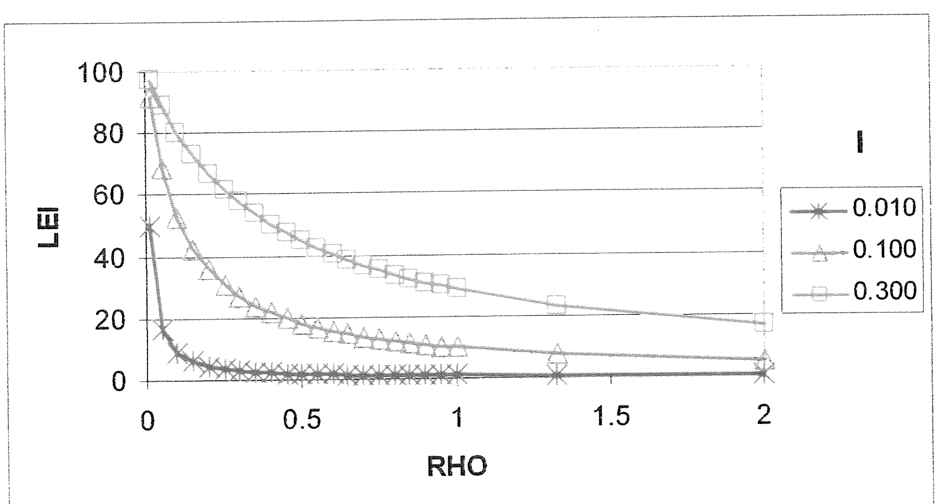

Figure 4. Trends in Alaska Essential Fish Habitat Effect and Recovery Model Long-term Effect Index (LEI) for a range of fishing intensity (I) and habitat recovery rate (ρ) parameter values.

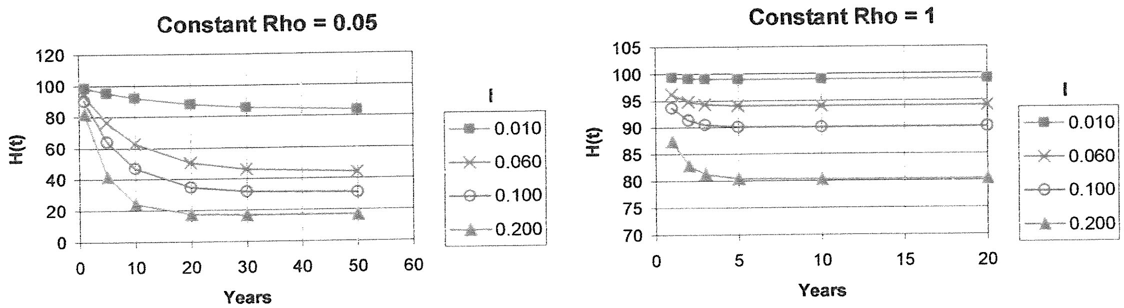

Figure 5. Time (years) necessary to reach an equilibrium habitat/fishery effect for fixed habitat recovery rate (ρ) and variable fishing intensity (I). (Assumes all habitat was unaffected by fishing at time 0).

9.0 TABLES

Table 1. Description of the range of parameter and outcome values used in the EFH model.

Name	Type	Quantity	Units	Qualitative Range		Value Range			
						Theoretical		Practical	
				More severe	Less Severe	Low	High	Low	High
Sensitivy rate	Parameter	q	none	Large number	Small number	0	1	0	0.35
Recovery rate	Parameter	Rho (ρ)	1/years	Small number	Large number	0	Infinity	0.005	1.33
Time to recovery	Parameter	$1/\rho$	years	Large number	Small number	0	Infinity	0.75	200
Effort index	Parameter	f	% area	Large number	Small number	0	Infinity	0	>1
Intensity rate	Parameter	I	% area	Large number	Small number	0	Infinity	0	0.3
Long-term Effect Index	Outcome	LEI	% habitat lost	Large number	Small number	0	100	0	100
Unaffected Habitat at time t	Outcome	H_t	% habitat present	Small number	Large number	0	100	0	100

Table 2. Estimated LEI values for a range of recovery rates (ρ) and fishing intensity (I). (The yellow shaded area represents loss of habitat features of more than 50%).

LEI	**Rho (ρ) values from Table B.2-6**						
I	**0.01**	**0.05**	**0.18**	**1**	**1.33**	**2**	**4**
0.001	9	2	1	0	0	0	0
0.010	50	17	5	1	1	1	0
0.040	81	45	19	4	3	2	1
0.060	86	56	26	6	5	3	2
0.080	90	63	32	8	6	4	2
0.100	92	69	38	10	8	5	3
0.150	95	78	49	15	12	8	4
0.200	96	83	58	20	16	11	6
0.300	98	89	69	29	23	17	9

Table 3. Interpolated stock biomass (1000 mt) as illustrated in Appendix H of the draft PSEIS.

			Interpolated from Figures in Appendix H of the PSEIS.				
	BSAI		Spawning Biomass			$B_{2002}/(0.5B_{35})$	B_{2010}/B_{35}
Species	Figure	Page	B_{35}	2002	2010		
Pollock	H4-1	H4-62	2410	3680	2400	3.1	1.00
P.cod	H4-2	H4-63	360	405	346	2.3	0.96
YFS	H4-3	H4-64	337	451	300	2.7	0.89
Greenland Turbot	H4-4	H4-65	48	68	35	2.8	0.73
Arrowtooth	H4-5	H4-66	183	476	310	5.2	1.69
Rocksole	H4-6	H4-67	137	331	137	4.8	1.00
Flathead sole	H4-7	H4-68	109	248	135	4.6	1.24
Alaska Plaice	H4-8	H4-69	114	277	275	4.9	2.41
Sablefish	H4-9	H4-70	27	29	26	2.1	0.96
POP	H4-10	H4-71	120	138	120	2.3	1.00
Atka mackerel	H4-11	H4-72	78	118	77	3.0	0.99
	GOA		Spawning Biomass			$B_{2002}/(0.5B_{35})$	B_{2010}/B_{35}
Species	Figure	Page	B_{35}	2002	2010		
Pollock	H4-12	H4-73	210	136	212	1.3	1.01
P.cod	H4-13	H4-74	79	98	78	2.5	0.99
Sablefish	H4-14	H4-75	67	73	64	2.2	0.96
POP	H4-15	H4-76	92	104	99	2.3	1.08
Thornyhead	H4-16	H4-77	15	24	24	3.2	1.60

10.0 APPENDIX I

50 CFR 600.815 (a) (2)

Fishing activities that may adversely affect EFH

(i) Evaluation. Each FMP must contain an evaluation of the potential adverse effects of fishing on EFH designated under the FMP, including effects of each fishing activity regulated under the FMP or other Federal FMPs. This evaluation should consider the effects of each fishing activity on each type of habitat found within EFH. FMPs must describe each fishing activity, review and discuss all available relevant information (such as information regarding the intensity, extent, and frequency of any adverse effect on EFH; the type of habitat within EFH that may be affected adversely; and the habitat functions that may be disturbed), and provide conclusions regarding whether and how each fishing activity adversely affects EFH. The evaluation should also consider the cumulative effects of multiple fishing activities on EFH. The evaluation should list any past management actions that minimize potential adverse effects on EFH and describe the benefits of those actions to EFH. The evaluation should give special attention to adverse effects on habitat areas of particular concern and should identify for possible designation as habitat areas of particular concern any EFH that is particularly vulnerable to fishing activities. Additionally, the evaluation should consider the establishment of research closure areas or other measures to evaluate the impacts of fishing activities on EFH. In completing this evaluation, Councils should use the best scientific information available, as well as other appropriate information sources. Councils should consider different types of information according to its scientific rigor.

(ii) Minimizing adverse effects. Each FMP must minimize to the extent practicable adverse effects from fishing on EFH, including EFH designated under other Federal FMPs. Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing activity adversely affects EFH in a manner that is more than minimal and not temporary in nature, based on the evaluation conducted pursuant to paragraph (a)(2)(i) of this section and/or the cumulative impacts analysis conducted pursuant to paragraph (a)(5) of this section. In such cases, FMPs should identify a range of potential new actions that could be taken to address adverse effects on EFH, include an analysis of the practicability of potential new actions, and adopt any new measures that are necessary and practicable. Amendments to the FMP or to its implementing regulations must ensure that the FMP continues to minimize to the extent practicable adverse effects on EFH caused by fishing. FMPs must explain the reasons for the Council's conclusions regarding the past and/or new actions that minimize to the extent practicable the adverse effects of fishing on EFH.

(iii) Practicability. In determining whether it is practicable to minimize an adverse effect from fishing, Councils should consider the nature and extent of the adverse effect on EFH and the long and short-term costs and benefits of potential management measures to EFH, associated fisheries, and the nation, consistent with national standard 7[3]. In determining whether management measures are practicable, Councils are not required to perform a formal cost/benefit analysis.

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[3] M-S Act NS 7, "Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication "

(iv) Options for managing adverse effects from fishing. Fishery management options may include, but are not limited to:

(A) Fishing equipment restrictions. These options may include, but are not limited to: seasonal and aerial restrictions on the use of specified equipment, equipment modifications to allow escapement of particular species or particular life stages (e.g., juveniles), prohibitions on the use of explosives and chemicals, prohibitions on anchoring or setting equipment in sensitive areas, and prohibitions on fishing activities that cause significant damage to EFH.

(B) Time/area closures. These actions may include, but are not limited to: closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities and designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life stages, such as those areas designated as habitat areas of particular concern.

(C) Harvest limits. These actions may include, but are not limited to, limits on the take of species that provide structural habitat for other species assemblages or communities and limits on the take of prey species.

11.0 APPENDIX II

Facsimile of a Memorandum from Dr. Marasco to staff.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Alaska Fisheries Science Center
Resource Ecology and Fisheries Management Division
BIN C15700; Building 4
7600 Sand Point Way NE
Seattle, Washington 98115-0070

October 4, 1999

MEMORANDUM FOR: Stock Assessment Authors

FROM: F/AKC3 - Richard Marasco

SUBJECT: Computation of status Determination criteria

Please find attached copies of an August 5 memo from Jim Balsiger to Steven Pennoyer and this year's North Pacific groundfish status determination report. As detailed in these attachments, the methods used to compute status determination criteria in groundfish stock assessments are undergoing some changes. It should be emphasized that none of these involves alteration of the ABC/OFL definitions contained in Amendments 56/56. However, computation of the quantities used in these definitions needs to be standardized, and the definitions need to be applied in some new ways.

For all assessments of North Pacific groundfish stocks that are managed under Tiers 1-3 of Amendments 56/56, here is the protocol that should be followed in preparing chapters for this year's SAFE reports:

1) Projections of future stock sizes and estimation of reference points should be based only on year classes spawned in 1977 or later, unless a compelling case can be made to begin the time series in some other year. The fact that earlier estimates are available does not in itself constitute a compelling case.

2) Projections of future stock sizes should be stochastic if possible. Authors should use their best judgment in determining an appropriate method to use in making projections.

3) A determination should be made as to whether the stock is below its minimum stock size threshold (MSST): This should be done as follows:

a) If the spawning biomass for 2000 is projected to be below

½ B_{MSY} (Tiers 1-2) or below ½ B35% (Tier-3), the stock is below its MSST.

b) If the spawning biomass for 2000 is projected to be above B_{MSY} (Tiers 1-2) or above $B_{35\%}$ (Tier 3), the stock is above its MSST.

c) If the spawning biomass for 2000 is projected to be above ½ B_{MSY} but below B_{MSY} (Tiers 1-2) or above ½ $B_{35\%}$ but below $B_{35\%}$ (Tier 3), the stock's status relative to MSST is determined by projecting the stock 10 years into the future under the assumption that catch=OFL in each year. If the spawning biomass for 2010 is expected to be below B_{MSY} (Tiers 1-2) or $B_{35\%}$ (Tier 3), the stock is below its MSST. Otherwise, the stock is above its MSST.

4} A determination should be made as to whether the stock is expected to fall below its MSST within two years. This determination should be made by projecting the stock 12 years into the future under the assumption that catch=ABC_{max} (i.e., the maximum permissible ABC under Amendments 56/56) for the first two years and catch=OFL for the next 10 years. If the spawning biomass for 2012 is expected to be below B_{MSY} (Tiers 1-2) or $B_{35\%}$ (Tier 3), the stock *is* expected to fall below its MSST within two years. Otherwise, the stock *is not* expected to fall below its MSST in two years.

Attachment